formity of sections for the entire class, thus greatly facilitating the work of instruction, and conserving the energy of both instructor and student.—AMON B. PLOWMAN, *Harvard University.*

ANATOMICAL NOTES ON CERTAIN STRAND PLANTS.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. LVIII.

THE following notes embody the results of a comparative study of the leaf anatomy of certain plants occurring on the Atlantic coast in the vicinity of Woods Hole, Mass., and also near Lake Michigan in the vicinity of Chicago, Ill. Several of the plants are typical strand plants, *e. g.*, *Cakile americana;* others frequently or even generally occur at a greater distance from the shore. A similar study ot French strand plants has been made by Lesage,[1] and the results recorded in the present paper largely confirm those of the earlier writer.

1. Plants growing in the maritime situation are found to have thicker leaves than the same species growing inland.

Plants	THICKNESS OF LEAF IN MM.	
	Inland	Maritime
Cakile americana	0.76	1.17
Lathyrus maritimus	0.28	0.32
Euphorbia polygonifolia	0.28	0.38
Xanthium canadense	0.39	0.60
Atriplex hastata	0.19	0.49
Hibiscus Moscheutos	0.13	0.23
Convolvulus sepium	0.24	0.31
Solanum nigrum	0.31	0.37
Polygonum aviculare	0.15	0.27

The foregoing measurements represent average thickness of different leaves and different parts of leaves. Since the Lake Michigan specimens were collected in June and the Woods Hole specimens in July and August, it was thought that the difference in time of collection of the inland and maritime material might introduce a source of error. Accordingly additional specimens of several species were secured in the Lake Michigan region in October, and these yielded the same measurements as those collected in June. It will be seen from the table that in some cases the maritime form is only slightly thicker than the inland form, while in other cases the former is nearly twice as thick. Measure-

[1] Rev. Gén. Bot. **2**: 55. 1890.

ments of fourteen species found only on the seashore or in the adjoining salt marshes showed that most of them possess thick leaves, while several cases merit the term succulent, *e. g.*, *Arenaria peploides* (thickness 3^{mm}); in this plant and several others the stem also partakes of the fleshy character.

2. This increase in thickness of the leaf is always due, at least in part, to an increase in thickness of the palisade layer; for example, in *Xanthium canadense* and *Atriplex hastata* the palisade is about twice as thick in the maritime form as in the inland form.

3. In some cases the number of palisade layers is increased in the maritime situation; for instance, *Convolvulus sepium* has two layers in the inland form, but three in the maritime.

4. Several species, such as *Atriplex hastata*, *Xanthium canadense*, and *Polygonum aviculare*, show a tendency to the isolateral form on the seashore, while they are distinctly bifacial when growing inland. In Xanthium the cells of the spongy parenchyma adjoining the lower epidermis are irregular in the inland form, but in the maritime form are elongated in a direction at right angles to the surface, forming a true palisade, which is more lacunar, however, than that on the dorsal side of the leaf. The only plant which showed the isolateral structure in both habitats is Cakile; this showed merely an increase in the number of layers of palisade cells in the maritime form. However, of the fourteen distinctly maritime plants mentioned above, only three showed the bifacial structure, viz., *Ligusticum scoticum*, *Artemisia Stelleriana*, and *Sabbatia stellaris;* so that the isolateral structure seems to be typical of the maritime condition.[2]

5. A marked increase in compactness of the mesophyll was observed only in *Convolvulus sepium;* several other species showed this character in a very slight degree.

6. Turning to the epidermis, the outer wall was found to be from one and a half to two times as thick in the maritime form as in the inland form in *Cakile americana*, *Lathyrus maritimus*, and *Atriplex hastata*, but did not exceed $7\,\mu$ in any of these cases.

7. The surface was found to be rougher in the maritime form in the case of *Euphorbia polygonifolia* and *Atriplex hastata*.

8. A noteworthy observation is the presence of hairs in the maritime form of *Lathyrus maritimus* and *Convolvulus sepium*, while no hairs were found in the inland form. The Convolvulus material collected on an exposed gravelly shore at Woods Hole showed long stiff

[2] WARMING, EUG., Halofyt-Studier 247.

dead (protective ?) hairs and knob-shaped partly sunken glands; the inland form showed only the glands. None of the true halophytes showed slender dead hairs, though a few, such as *Buda marina*, possess glandular hairs. *Artemisia Stelleriana*, found in the same habitat as Convolvulus, has a dense covering of long silky hairs.

9. The stomata were examined with respect to distribution on the two surfaces, level with regard to the surface, and form. The only significant point observed is the presence of a few stomata on the upper surface of Convolvulus in the maritime form, while stomata are confined to the lower surface in the inland form. This observation does not support the accepted view that conditions on the maritime strand are essentially xerophytic, for so-called xerophytic leaves usually have stomata only on the under surface. Moreover, out of twenty-four species found near the shore at Woods Hole, all but three (viz., *Ligusticum scoticum*, *Artemisia Stelleriana*, and *Sabbatia stellaris*) have stomata on both surfaces. In seventeen species the stomata are level with the surface, in three sunken less than half the thickness of the epidermis, in four (viz., *Euphorbia polygonifolia*, *Atriplex hastata*, *A. arenaria*, and *Polygonum maritimum*) sunken half or more than half the thickness of the epidermis.

The differences noted in the foregoing paragraphs point with few exceptions to a more xerophytic structure in the leaves of the maritime specimens than in those of the inland specimens of the same species. Since most of the conditions on the strand of Lake Michigan are very similar to those on the Massachusetts coast, it is natural to look to presence of salt in the soil or in the air as the cause of the differences observed. To further test this point specimens of *Solidago sempervirens* were collected from stations (1) as near as possible to the strand, (2) one hundred feet back from the water's edge, on the slope of a hill, (3) on the edge of a marsh bordering a brackish pond. The leaves presented the same structure in all three cases, but the average thickness was as follows: from (1) 0.50^{mm}, from (2) 0.36^{mm}, from (3) 0.56^{mm}. There are evidently several factors of which account must be taken in dealing with figures such as these, but the observation seems plainly to support the assumption that the amount of salt present influences the thickness of a leaf. Measurements were also made of leaves of *Statice Limonium* collected from four situations whose salt content was estimated by titration with silver nitrate. The results of this set of experiments show a general correspondence between thickness of leaf and saltiness of substratum, but the results are not altogether trustworthy

because of the inconstancy in amount of salt in a salt-marsh during the growing season.—M. A. CHRYSLER, *The University of Chicago.*

CHROMOSOME REDUCTION IN LILIUM CANADENSE.

THE investigations, a brief résumé of whose results is given below, were carried on upon the dividing pollen mother-cells of *Lilium canadense* L., collected in the vicinity of Madison during the past five summers. A fuller account, with figures, is practically completed, but as it must be some time before it appears in print, and as the results are in some points quite different from those obtained by any previous observer, it seems advisable at this time to publish a brief statement of my observations.

After the completion of the division which forms the pollen mother-cell, there is a long period during which the cell and nucleus increase greatly in size. The nucleus contains during this period, in addition to the nucleoles, numerous irregular masses of considerable size, connected by narrow strands or fibers, the whole forming an extremely irregular network. In preparations stained with Flemming's triple stain, the larger masses show an affinity for the safranin, the fibers for the violet. There are also numerous short, fine, blue-staining fibers attached to the larger bodies, giving the network a ragged appearance.

This general arrangement persists until just before the passage of the nucleus into the condition of synapsis, when the blue-staining fibers begin to grow longer and to become more uniform in thickness; at the same time the larger masses or knots decrease in size. While these changes are going on, it is evident in many portions of the network that two fibers lie side by side and parallel; sometimes such parallel strands are attached at their corresponding ends to the same red-staining mass. While this rearrangement or pulling out of the nuclear material into threads is going on, all of the chromatic nuclear substances become massed against one side of the nuclear membrane, resulting in the synaptic figure so often described. The formation of the spirem is not fully completed until after the occurrence of this eccentric massing; there is, therefore, in this case no "dolichonema" stage preceding synapsis.

As has been said, while the spirem is being formed, it is seen in many places to consist of two parallel threads; and this continues to be the case until all of the staining substance within the nucleus, excepting the nucleoles, has been distributed along the spirem. In